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H. E. CLAPHAM, *Editor*

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THE AUTOMATIC SPECIAL SERVICE DESK

By H. W. BALZER

SYNOPSIS: *Need for improved desk—general description—link equipment—keyshelf equipment—switch equipment—intercept concentration—staffing and operational procedures—group identity lamps—extending calls to supervisor and line equipment—call answering sequence—group marking control circuits—guards against false conditions.*

THE equipment placed at the disposal of special service operators for the answering of information and intercept calls has remained basically unchanged for many years. While the desks themselves have been redesigned from time to time, and the record files improved to afford the operators easier access to needed information, the method of providing a separate talk key for each circuit that the operator is to handle has become traditional, and the keyshelf with its long row of keys has continued to follow the familiar pattern.

With the steadily increasing demand for more service at higher speeds, there has developed a definite need for improved facilities for handling information and intercept calls. This is particularly true of multi-office exchanges where such services are centralized. To meet this need, Automatic Electric Company has developed the Automatic Special Service desk described in this article.

As its name implies, the new desk makes wide use of automatic switching principles and apparatus. It is, in fact, as nearly automatic in operation as it was thought practical to make it. The traditional key-ended circuits have been eliminated in favor of a Strowger finder switch, which automatically supplies traffic to the operator from a large number of trunks. One advantage of this is that it greatly increases the number of trunks available to the operator. On older types of desks, the number of trunks to which an operator has access is limited to the number of keys that can be mounted on a key shelf. With the new desk, an operator may have access to a large number of trunks, with only a few keys on the keyshelf.

Figure 1—Automatic Special Service Desk (8-position) of Home Telephone and Telegraph Company, Fort Wayne, Indiana.

Both the circuit design and method of operation of the Special Service Desk follow very closely those of the Automatic (cordless) Toll Board now in wide field use, except that the type of traffic handled has permitted simplification in various ways. As with the toll board, all automatic switching equipment is mounted on racks in the switch room. The operator's desk is provided with only a few keys and lamps, with a terminal block for cabling the desk equipment to the switch room equipment. Since only a small space is taken up by the key and lamp equipment, the design of the desk may be varied as desired, depending upon the type and arrangement of information records used by the exchange in which it is installed. Figures 1 and 2 illustrate the design of one typical desk.

Link Equipment

The keyshelf of the Automatic Special Service desk is designed so that an operator has before her only two talk keys, each of these associated with a Strowger finder. Each talk-key-and-finder combination is referred to as a *link*, because through it the operator is "linked", or connected, to the trunk circuit. Normally, all traffic is handled over the first of the two links; however, in situations where excessive time is required to handle a call, additional calls may be handled on the second link. This method is parallel to standard operating practice on special service desks having the older key-ended circuits.

The second link is used also to handle traffic while the first link is in use on a call extended to the supervisor. In addition, provision is made for the extension of either link to line equipment, when required by the operating company; in this case the second link handles new traffic while the first is extending a subscriber call. However, this method of operation is not recommended.

Keyshelf Equipment

A typical keyshelf layout for the new automatic desk is shown in Figure 3. The first two escutcheons provide desk link equipment, each with a talk-release key, a busy lamp (to indicate when that link is connected to a trunk) and a supervisory lamp.

The third escutcheon contains a night-alarm key (which appears in only one operator's position of

a multiple setup) and a common release key. When an operator has disposed of a call, the connection may be released by operating the link talk-release key momentarily or by operating the common release key while leaving the link talk-release key operated. The common release key is associated with either link, when the talk key in that link is in an operated position.

The fourth escutcheon contains a start alarm lamp, an emergency start button, and a flash key. When a call has been assigned to the desk for handling, but the finder for some reason fails to answer the call, the start alarm lamp lights after a predetermined length of time. This lamp is individual to each operator's position in a multiple setup, and will light only in the position that is blocking traffic. When trouble appears in this way, an audible alarm sounds in the switch room, and the position in trouble is indicated.

In case of blocking trouble in the common equipment, operation of the emergency start key permits the operator to handle calls. The flash key, in the same escutcheon, is associated with the link on which a talk key is operated, and is used to recall a toll operator on toll connector intercept calls.

The fifth, sixth and seventh escutcheons contain answer pilot lamps, class of service keys, a local and link dial key, and a local hold and dial release key.

The local and link dial key has two positions. When operated to the local dial position it connects the operator's position equipment to a line circuit. This line circuit may then be used to originate calls to the automatic switch equipment. When operated to its link dial position this key associates a link (on which the talk key is operated) with line equipment for extending a call.

When it is necessary to restore the local dial key to normal without releasing the local dial connection, the local hold key is operated. When operated to its dial release position, this key releases a connection set up on a link having the talk key operated, without releasing the calling subscriber.

Class of Service Keys

The three "class of service" keys mounted on the fifth, sixth and seventh escutcheons control the

Figure 2—Detail View of One Position of Typical Automatic Special Service Desk.

classes of calls handled by the position at any one time. There is a separate key for each of the service classes handled—toll information, local information, and intercept. When any one of these keys is in the "off" position, the desk is blocked to the service controlled by that key. Thus, the keys can be set to enable the operator to handle all classes of service, or any combination of the three classes, the choice depending upon traffic requirements at the time.

Answer Pilot Lamps

Associated with each class of service key, and mounted above it on the same escutcheon, is an answer pilot lamp. This lamp glows when an incoming call in that class is waiting to be handled. When a class of service key is operated to the "off" position, its corresponding answer pilot lamp is disconnected.

Supervisor's Equipment

The last escutcheon contains equipment necessary to extend a call to the supervisor, the equipment consisting of a busy lamp, a supervisory lamp, and a supervisor release key. The busy lamp

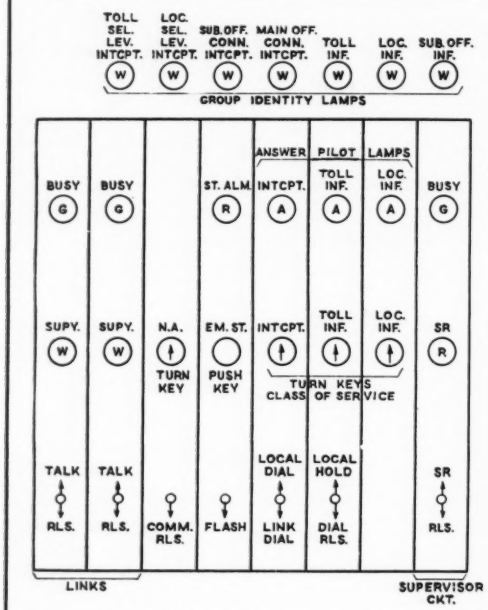

Figure 3—Typical Keyshelf Arrangement—Automatic Special Service Desk.

glows when the supervisor's circuit is in use, and is multipled to all positions within a section. The supervisory lamp indicates when the supervisor has answered or disconnected, and glows only at that desk in a section which has extended a call to the supervisor. The supervisor release key, when operated to its supervisor position, associates a link on which the talk key is operated with the supervisor; when operated to its release position it releases the supervisor's circuit without releasing the link.

Group Identity Lamps

Just above the escutcheons is mounted a set of group identity lamps, which light independently at each desk in a section. Each time a call is answered on the desk, one of these lamps glows to indicate the type of service to be handled on that call. As shown in Figure 3, these lamps would normally be designated "toll information", "local information", "sub-office information", "main office connector intercept", "sub-office connector intercept", "local selector level intercept", and "toll selector intercept"; however, these designations may vary, depending upon the requirements of the particular installation. As many as ten different group identity lamps may be provided to identify ten different services.

Switch Equipment

A schematic diagram for a typical Automatic Special Service Desk is shown in Figure 4. The common start circuit, position distributor, supervisor's circuit and verification trunk circuit are all common to the various positions. The operator's position circuit and link are individual to each position, and the operator's telephone circuit is part of the position circuit. Trunk circuits are connected according to the types of calls to be handled.

Each trunk circuit is composed of three wires ("tip", "ring", and "C" leads) connected to the bank terminals of the Strowger finder. These leads are multipled to the Strowger finders for all operators, so that all desks in a multiple setup have access to any trunk circuit. Each trunk circuit also has a start lead, which is closed when a call is originated; this lead is connected to the common start circuit. As many trunk start leads may be multipled as there are contacts in a group across a level of the Strowger finder; for instance, in a 100-point linefinder, 10 trunk start leads, corresponding to the ten contacts across a level, may be multipled.

The common start circuit performs three basic functions. When a start lead from a trunk circuit is closed, the common start circuit provides a "marking" for the vertical bank of the Strowger finder corresponding to the level on which the trunk is located. An answer pilot lamp, corresponding to the class of call originated, is caused to light at all operators' positions which are conditioned to handle calls of this class. A marking is also extended to an idle operator's position circuit, and the master "group marking" control circuit, corresponding to the class of service functions. Operation of the "group marking" control feature will be explained in detail later in this article.

The position distributor, as its name suggests, is equipment which allots incoming calls among the positions of a multiple setup. Calls are allotted in rotation, so that no one operator will be required to handle more than her share of the traffic. So that calls may be received simultaneously in the three classes of service, three separate position dis-

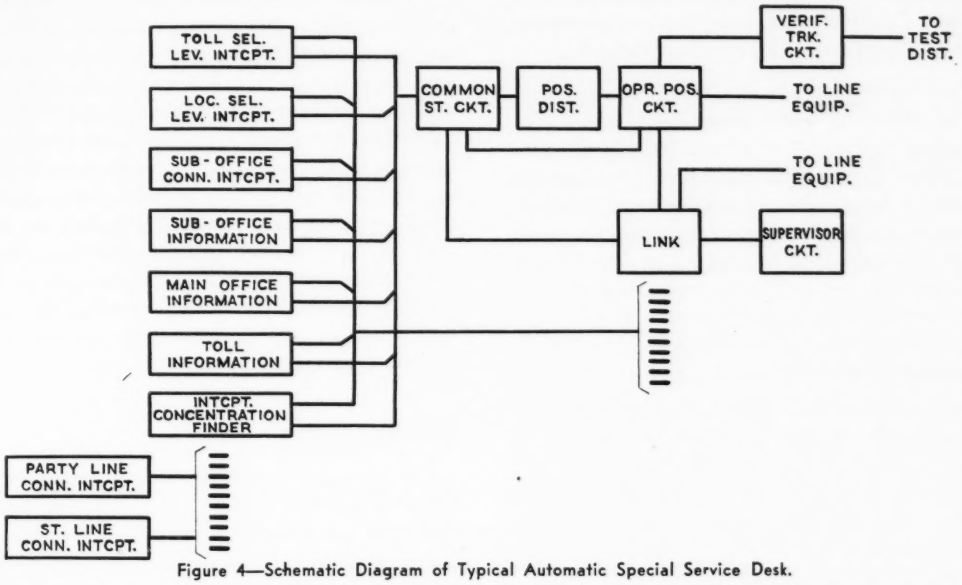

Figure 4—Schematic Diagram of Typical Automatic Special Service Desk.

tributors are provided—one for each class of service handled.

All keys in an operator's position are ineffective unless a headset is "plugged in"; therefore, when an operator vacates her position and unplugs the headset, that position becomes "dead" and will not in any way interfere with the normal flow of traffic to other operators, regardless of any keys left operated on the vacant position.

Intercept Concentration

As shown in Figure 4, all connector intercept is concentrated through a finder switch, which is in turn connected to the banks of the operator's link finder as would be any other trunk circuit. The intercept concentration finder is normally a 200-point switch, which means that two hundred connector intercept trunk circuits are concentrated to a few bank contacts of the operator's link finder. A similar concentration finder is used in the sub-offices, the intercept calls being trunked to the main office over two-wire circuits.

Staffing The Position

To staff a position, the operator inserts the headset plug and sets the class of service keys to the services to be handled at that desk. She then operates the link talk key, and this causes her position to be marked idle to the position distributor, which will allot a call to her position in its turn.

Receiving Calls

When a subscriber originates a special service call, he causes an idle trunk circuit (corresponding to the type of call) to be seized. This seized trunk circuit places a marking potential on a contact of the Strowger finders, and causes the common start circuit to function. A finder, associated with the operated talk key of a non-busy link within the position allotted to answer the call, automatically finds the marked circuit. The functioning of the common start circuit and position distributor permits only one finder to search for a call within any one class of service. When the finder seizes the calling trunk, relay operations within the link extend the call to the operator's position equipment. Relays then function in the operator's position equipment to cause an "acceptance tone" to be transmitted to the operator's headset, informing her that a call has been received and is ready to be answered.

The link busy lamp lights when the finder seizes

the calling trunk, and remains lighted for the duration of the call; this guards against attempted re-use of the link before the call is released.

In case no operator is idle, the incoming call is held in abeyance, and answer pilot lamps corresponding to the class of service light at all positions. These lamps serve as a signal to indicate that one or more calls are waiting to be handled. As soon as any operator becomes available whose position is conditioned to answer the class of call that is waiting, the call is automatically connected to her position.

Acceptance Tone

The acceptance tone may be varied (by strapping within the operator's position equipment) to produce a "zip-zip" tone for one class of call, and a steady tone for another class. Since only information and intercept phraseology is required, these two types of tone will indicate to the operator the challenge she must use in answering.

Operation of Group Identity Lamps

The group identity lamps at the operator's position are associated with the trunks, which are classified according to their service. When the link talk key is operated, relay operations within the link and operator's position cause the proper identity lamp to light automatically, which permits the operator to identify the type of call, more specifically than provided by the acceptance tone. As mentioned above, there are a maximum of ten group identity lamps; these are not multipled between operator's positions, and therefore light only in the position which has answered the call.

Extending Call To Supervisor

To extend a call to the supervisor, the link talk key is left in the talk position, and the common supervisor's key is operated momentarily to the "SR" position. Operation of this key signals the supervisor in two ways: a buzzer sounds as long as the "SR" key is operated or until the supervisor answers, and a supervisor's call lamp lights. These signals are common to the supervisor's section of the switchboard. Operation of the key also lights an "SR" lamp at this position, and a supervisor busy lamp at each operator's position, to warn other operators against intruding on the supervisor's circuit.

To answer, the supervisor plugs her headset into the supervisor's jack at any position, which extinguishes the "SR" lamp at the calling position, and the supervisor's call lamp. A three-way conversation can now be carried on among the calling subscriber, the operator and the supervisor, or the operator may retire from the connection by restoring her link talk key to normal. The operator's link busy lamp will remain lighted until the call is released, and she may return to the connection by reoperating her link talk key to its talk position. While this first link is in use extending the call to the supervisor, the operator may use the second link circuit to handle calls.

Releasing Calls

On information calls that have been extended to the supervisor, the link and the supervisor's circuit will automatically release when the calling party disconnects. If the call is of another type, which does not automatically release the link, the supervisor's circuit provides disconnect supervision; the operator can then release the supervisor's circuit by operating her supervisor release key, or she can release the entire connection by operating her link release key.

On the majority of calls, which are not extended to the supervisor, the operator releases the connection by leaving her link key operated to its talk position, and operating momentarily her common link release key. This releases the call, and the position is immediately made ready to accept a new call. Thus, with this method of operation, the operator's position is always available for a new call as soon as the link releases, without the necessity of reoperating the link talk key. The time saved permits the operator to handle more calls.

On conventional, non-automatic special service desks, the operator must, in order to release calls, restore the talk key of the calling trunk; to answer a new call, she must operate the talk key of a waiting trunk. With the Automatic Special Service Desk, however, all these operations are taken care of by momentary operations of the common link release key. This feature is equivalent to the "automatic answering" feature provided on Automatic Toll Boards.

Extending Calls To Line Equipment

Each link is provided with means for extending an incoming call to line equipment when required. To extend a call to line equipment, the link talk key is left operated to the talk position, and the "link dial" key is operated. Operation of this key causes line equipment to be seized; the operator then proceeds to dial the desired digits. After dialing is completed, the "link dial" key is restored.

In case an error is made in dialing, or for some other reason, it is desired to release the line equipment, the "link dial" key is restored to normal and the "dial release" key is operated momentarily. This causes release of the associated switch train which was dialed up.

Calls From Operator To Line Equipment

The operator's position is provided access to line equipment, enabling her to call out without using the link circuits. To make such a call, she operates the local dial key, which seizes the line equipment and allows her to dial the desired number. If it is necessary to restore the local dial key without releasing the called connection, she operates the "local hold" key, which will disconnect the call from her position, yet hold it for further handling.

Sequence of Answering Calls

Service on the Special Service Desk is divided into three classes—toll information, local information and intercept. This division allows segregated handling of the three classes of service at the operators' positions, under control of positional class of service keys. Each operator's position has three classes of service keys, one for each class associated with a position.

Group Marking Circuits

In order to provide equal answering service to incoming calls, the "group marking" method of call distribution is built into the design of the Automatic Special Service Desk. With this method, incoming calls are "marked" by groups; that is, they are held in abeyance as a group, and fed to the operator for handling as a group. Thus, each group is disposed of completely before another marked group is released for handling.

Each class of service has associated with it (within the common start circuit) an individual "group marking control circuit", which is independent of the other classes of service. In addition, each class of service has an individual "position distributor circuit", independent of the other classes, which distributes the incoming calls among idle positions.

These three group marking control circuits control both the horizontal and vertical marking of the link finder banks. Each circuit controls one class of service. The three control circuits operate independently of each other.

In addition to the three group marking control circuits associated with the incoming classes of service, there is at each position another "group marking" control circuit which controls calls coming into that position. This circuit treats all incoming calls as one group, regardless of their service class. All calls to a desk from the position distributor are "marked" as a group by this latter control circuit. While the position is handling this group, no new calls allotted to the desk may be handled until the group is completely answered. This process gives all selected classes of service equal access to the desks. The position group marking control circuit permits segregated answering in some positions and combination answering in others; those positions arranged for combination service handle all incoming classes as one group.

Order of Answering Arrangements

A very flexible scheme has been devised for the desk whereby any order of answering for the three classes of service may be arranged. A position may be arranged so that any one class of service is given preference over the other two, the latter being handled only if the preferred class has no calls waiting. (This permits a position to operate as segregated service, answering one class as first choice, and acting as an overflow position to the other two classes.)

A desk may also be arranged to answer the three classes of service in any order. For instance, one position may be arranged to answer toll information first, local information second, and intercept third, or any other sequence. The order of answering of classes within a position is determined by the arrangement of strapping within the position relay equipment; this strapping may easily be changed as desired by the operating company.

By means of the class of service keys located at each position, any service or combination of services may be excluded from a position. These keys permit a position to operate segregated during heavy traffic or as a combination position during light periods.

Operation of Group Marking Controls

As mentioned before, each class of service is associated with a master group marking circuit. This circuit operates as follows:

If no calls are waiting to be answered in a class of service, when an operator becomes available, an incoming call will immediately be marked for operator acceptance. This call constitutes a "group" which is made available to the operator for handling. If new calls arrive while this initial call is being handled, they are blocked against being marked and are instead held in abeyance until the first group is completed, releasing the block. The calls which have been collected in abeyance constitute a second group, which are now marked for operator acceptance by the master group marking circuit and are handled one at a time in the order in which they appear on the finder bank. In the meantime, new calls appearing are blocked and held in abeyance as before, awaiting completion of service on the second group of calls.

The above arrangement makes possible the clearing of all calls in one class, in group sequence.

The position group marking circuit makes possible the handling of all calls sent to a single desk (combined classes) in marked groups. This method gives the desk equal access to all groups which the position is arranged to answer, without giving one group preference over the other (unless strapping has been provided to give one group preference.) Each position is conditioned to allow (at a certain instant) any one or all three groups in which calls are waiting to be marked. That position is immediately blocked to additional markings until all calls in the marked group or groups have been answered.

When a class has been blocked to a position by the operation of the class of service key to the off position, that class is removed from the operator's "group marking" control circuit. The blocked class becomes completely disconnected from that position, without interfering in any way with the marking and answering of the remaining two (unblocked) classes of service.

Guards Against False Conditions

The desk has been so designed that neither a falsely grounded trunk start lead, an open "C" lead to the link finder banks, nor an open vertical bank marking will block traffic to the board.

Should the link finder receive a vertical bank marking, but find no horizontal marking, it will rotate to the eleventh bank contact. The circuits are arranged so that when the link finder rotates to the eleventh contact (on any level except the tenth) the common start circuit functions to remove the link finder vertical bank marking on that level, which allows that level to be passed so that other marked calls can be answered.

On the tenth level, however, the link finder always cuts in, because the tenth vertical bank contact is permanently grounded. Whenever a link finder rotates to the eleventh bank contact in this, all three of the master "group marking" control circuits are released, and new levels may be marked for answering. A level in fault is not permanently locked out, but is allowed to come in each time a new group is cleared. After all legitimate calls are cleared on the level in fault, that level is released by rotation of the link finder to the eleventh step. This arrangement makes necessary only one extra finder operation to handle regular traffic when a faulty level is encountered.

Conclusion

The Automatic Special Service Desk is designed for maximum flexibility, to meet the requirements of the greatest amount of variation in operating practices. Any desk in a multiple setup may be instantaneously conditioned to provide segregated service during periods of peak traffic load, or combination service during light load periods. It may be operated as segregated for one class of service, while serving as an overflow position for either one or both of the other service classes. Practically any arrangement required by a particular installation may easily be obtained; or the arrangement can be changed as operating loads for the three services vary. To provide uninterrupted service, the desk has been designed for maximum dependability and ease of operation.

SWITCHING SELECTOR-REPEATERS IN MULTI-OFFICE NETWORKS

By N. SALVESEN

SYNOPSIS: *Typical network of main and branch offices—universal numbering requirements—an earlier solution — functions of the switching selector-repeater — the rotary out-trunk switch—completing the local call—a call to the main office—a call elsewhere—trunks to toll board — switching on the third digit — digit-absorbing selectors — use of holding bridges—direct trunking to two main offices — advantages of the switching selector-repeater.*

MULTI-OFFICE automatic exchange networks generally comprise "main" and "branch" offices; main offices have direct trunks between them, while a branch office, generally, has trunks only to and from the main office of which it is a branch. Exceptions to this are found in cases where the community interest is such as to warrant direct trunks from a branch office to other offices; also in very large and complex networks, wherein "tandem" offices would be employed for trunking between main offices. Such large networks, however, would undoubtedly require "Directors"* and are therefore considered to be beyond the scope of this article.

The reasons for establishing branch offices rather than main offices in a network are generally dictated by economic considerations arising from such problems as the geographical location of the proposed office, number of lines to be installed, community interest, efficient use of outside plant, subscribers' numbering plan and other factors which would make impractical direct trunking to all other offices in the network.

Universal Numbering Requirements

A typical network of four main offices (2, 3, 4 and 5) and three branch offices (2-9, 5-8 and 5-9) is shown in Figure 1. Each main office is a ten-thousand terminal unit, and each branch office shares the ten-thousand subscribers' numbers assigned to the main office of which it is a branch.

A branch office subscriber, upon removing the handset from his telephone, must be able to obtain connection with any subscriber in the network by dialing the listed directory number. Since the branch office does not have direct trunks to all other offices in the network, the equipment in the branch office must therefore be so designed that the calling subscriber, upon removing the handset from the telephone, immediately is connected to a first selector in the main office, without dialing any prefix to the wanted number.

In the earliest type of branch offices it was the general practice to locate the branch office first selectors in the main office and the multiple banks with the main office first selectors. Such an arrangement is shown in Figure 2, using the No. 2 main office, and the No. 2-9 branch office in Figure 1 as an illustration of the numbering plan. The objectionable feature of this arrangement is that each local call within the branch office requires the use of two main office trunks. In very small branch offices, where only a small percentage of the originating traffic is comprised of local branch office calls, this objection may not be very serious. However, as the office grows and local calls increase, the arrangement becomes less desirable.

Function of Switching Selector-Repeater

In order to overcome the objectionable feature of using main office trunks on local branch office calls, a switch known as the "switching selector-repeater" was developed. This switch combines into one mechanism the functions of a selector and of a repeater. Built into it is a discriminating feature which enables it to determine from the

*See Automatic Electric Company's Engineering Notes 2021 "The Strowger Automatic Director System" by F. L. Kahn.

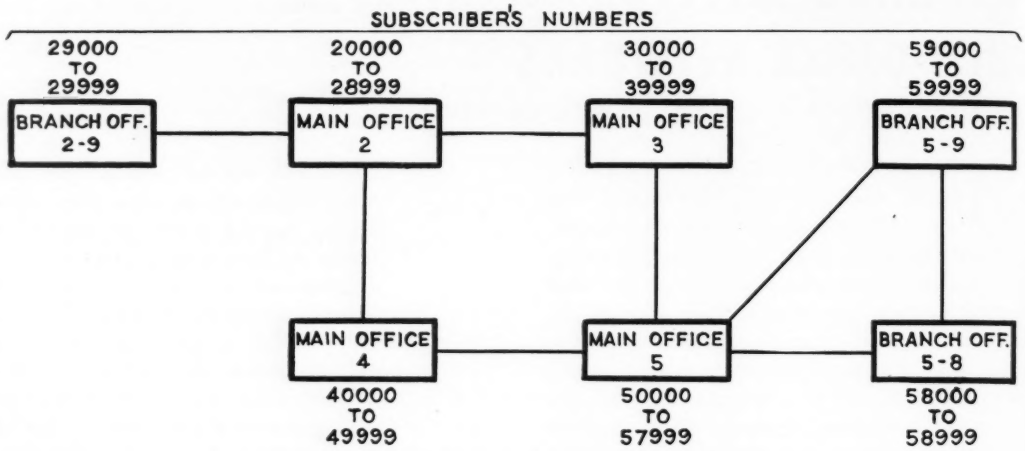

Figure 1. Typical Network of Main and Branch Offices.

digits dialed the functions required to complete a particular call; that is, whether to repeat impulses to switches in other offices or to switch through to switches in the branch office, or to trunks to the toll board.

The position of a switching selector-repeater in the switch train is that of a first selector; that is, it is directly connected to a linefinder. The principal functions of a switching selector-repeater may, perhaps, best be understood by referring to Figure 3. The type of switching selector-repeater shown in Figure 3 switches on the first or second digit, as determined by the digit dialed. (By "switching" is meant the function of rotating the wipers in on the bank contacts of the dialed level and hunting for an idle trunk on that level). This is, perhaps, the most commonly used type.

The switching selector-repeater shown in Figure 3 will have its markings set to switch on the first digit when "0" is dialed as the first digit, and to switch on the second digit when "9" is dialed as the second digit of a local branch office number. On all other calls the switch will merely function as an automatic-to-automatic repeater.

Rotary Out-Trunk Switch

Associated with each switching selector-repeater is a rotary out-trunk switch which, when seized, will hunt for an idle inter-office trunk terminating on an incoming first selector in the main office.

When a calling branch office subscriber is connected through a linefinder to a switching selector-repeater, the rotary out-trunk switch will find an idle trunk to the main office and the calling subscriber will receive dial tone from the incoming first selector in the main office .If all trunks to the main office are busy, the calling subscriber will receive dial tone from the switching selector-repeater, since local branch office calls can be made even though all trunks to the main office are busy. However, if the call is to a subscriber in any of the other offices, and all trunks to the main office are busy, the calling subscriber will receive the busy tone.

Completing Calls

In response to the first digit dialed, the switching selector-repeater and the incoming first selector will operate in unison to the level corresponding to the digit dialed. If the calling subscriber wishes to place a toll call, and dials "0", the switching selector-repeater will rotate in on the "0" level and signal the toll operator (switching on the first digit). Simultaneously the switch will cause the main office trunk to be disconnected, thereby releasing the incoming first selector in the

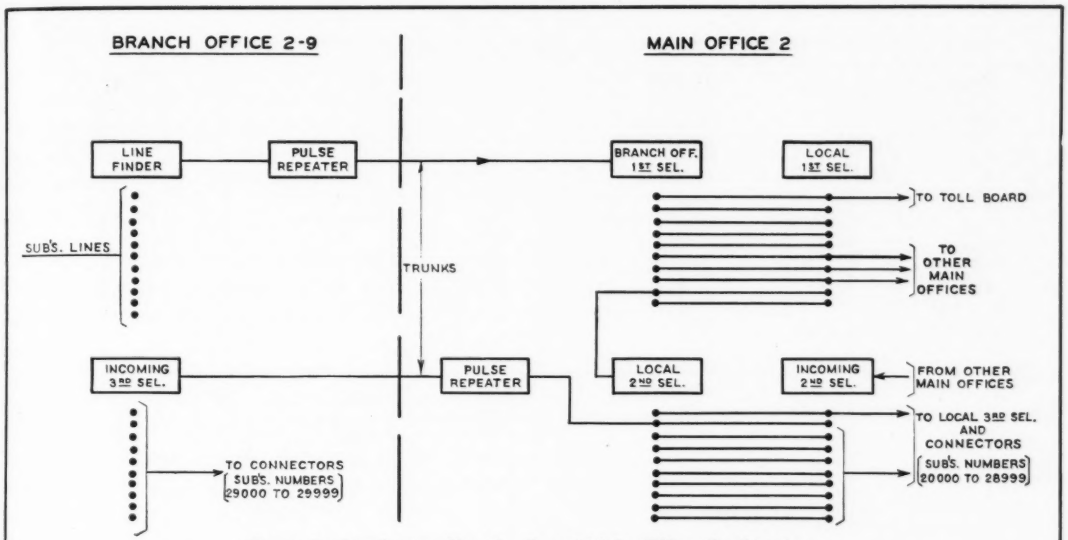

Figure 2. Numbering Plan for Branch-Main Office Combination.

main office and making the trunk available for another call.

If the call is to a local branch office number, as for example 29634, the first digit, "2", will operate both the switching selector-repeater and the incoming first selector in the main office to the second level. The incoming first selector will extend the connection to a local second selector. As both the main office and the branch office subscribers' numbers start with "2", the incoming first selector in main office will remain operated, since the call might be to a main office subscriber. The switching selector-repeater, however, will release and return to normal. When the second digit "9" is dialed, the switching selector-repeater and the local second selector in main office will step in unison to the ninth level. By its circuit marking, the switching selector-repeater will recognize this as a local call and will rotate in on the ninth level and extend the connection to a local third selector (switching on the second digit). Simultaneously, the switching selector-repeater will cause the re-

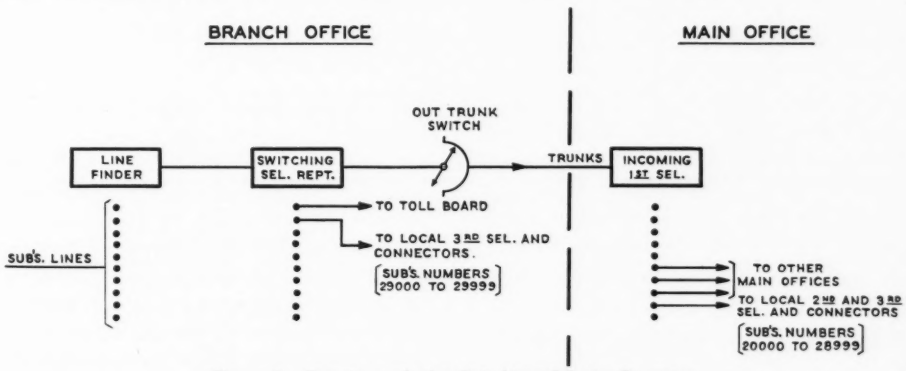

Figure 3. Functions of the Switching Selector-Repeater.

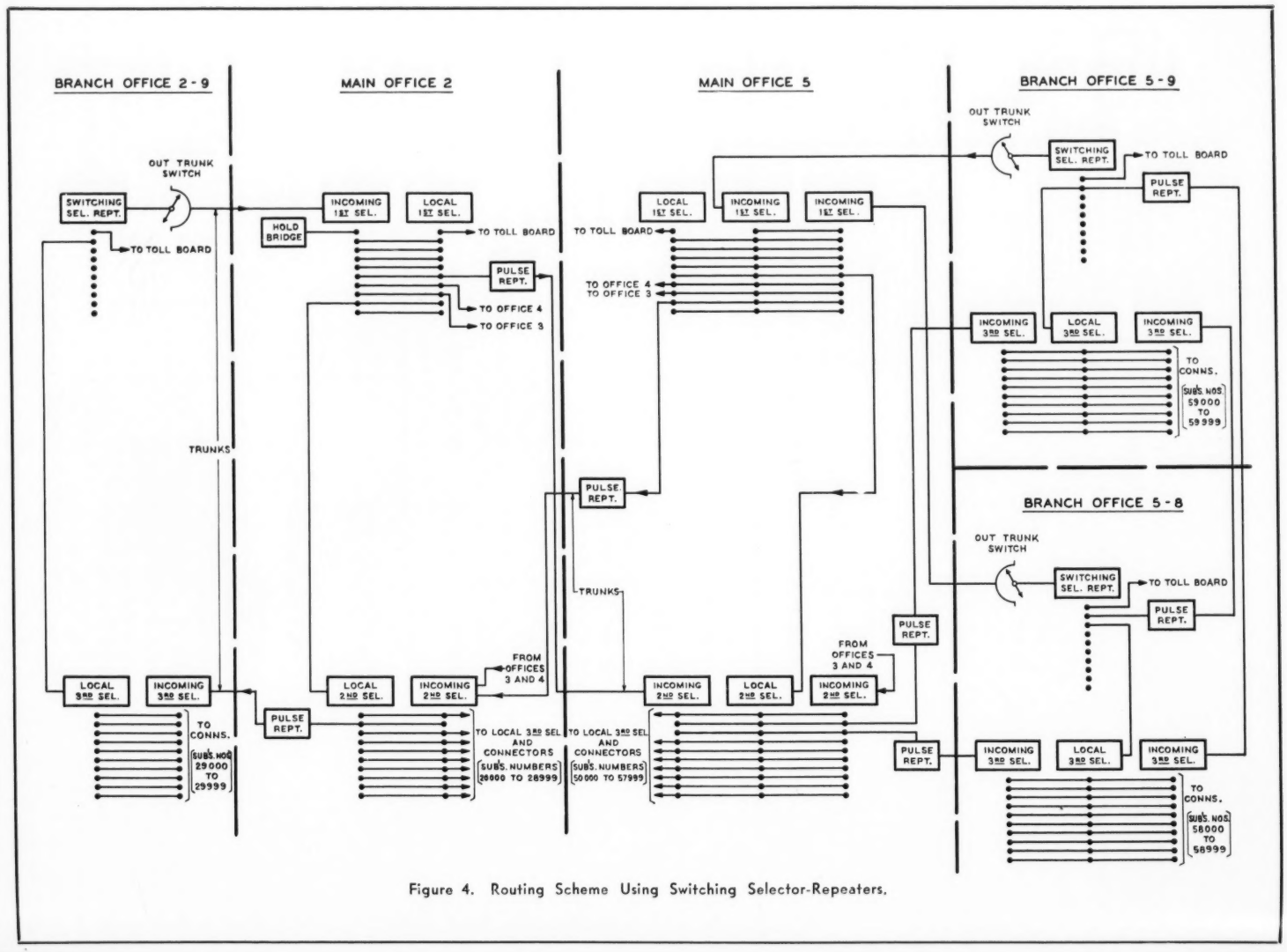

Figure 4. Routing Scheme Using Switching Selector-Repeaters.

lease of the main office trunk, thereby restoring the incoming first selector and the local second selector in main office to normal, and freeing the main office trunk for another call. The dialing of the remaining three digits 6-3-4 will operate the branch office local third selector and connector in the customary manner to the terminal of the called line.

If the call is to a main office subscriber, the second digit will be a digit other than "9", and the switching selector-repeater will identify this as a main office call. In response to the dialing of the second digit, the wipers of both the switching selector-repeater and the local second selector in the main office will be stepped up to the dialed level, and the local second selector in the main office will extend the connection to a local third selector. During the remainder of the call the switching selector-repeater merely functions as a repeater, repeating the dialed impulses in the customary way to the main office third selector and connector, thus completing the call to the wanted subscriber.

If the call is to a subscriber in another main office, or in a branch office connected to another main office, the switching selector-repeater will recognize this by the first digit dialed, which will be a digit other than "2". In response to the dialing of the first digit, as for example "5", the switching selector-repeater and the incoming first selector in the main office will step in unison to the fifth level. The incoming first selector will rotate in on the level and select a trunk terminating at the No. 5 office on an incoming second selector. During the remainder of the call the switching selector-repeater will merely function as a repeater, as described in the preceding paragraph.

Figure 4 shows diagrammatically and in more detail the routings of the classes of calls described in the preceding paragraphs. This figure is a partial schematic diagram of the trunking and numbering plan shown in Figure 1. It will be noted that branch offices No. 5-8 and 5-9 are connected by direct trunks. This arrangement is predicated on the assumption that the community interest between subscribers in the two branch offices is sufficiently high to warrant direct trunks, rather than to tandem such calls through the No. 5 main office. The operation of the switching selector-repeater on direct trunked calls between the two branch offices is the same as on local branch office calls; that is, the switching selector-repeater will switch on the second digit and select a trunk to an incoming branch office third selector, and release the main office trunk.

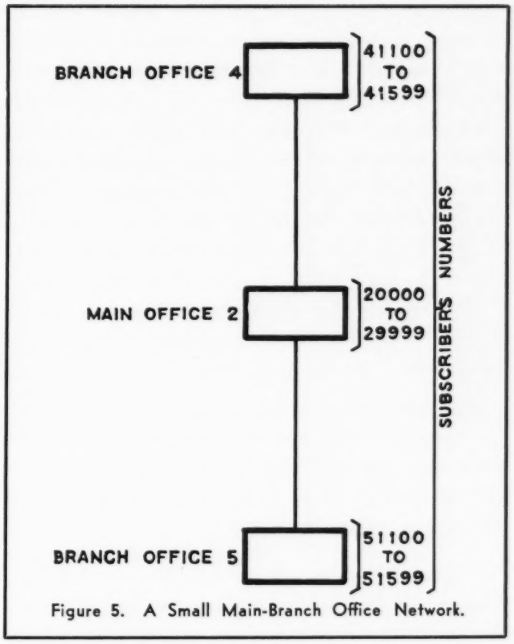

Figure 5. A Small Main-Branch Office Network.

It will be observed from Figure 4 that separate groups of C.L.R. trunks are shown extending from the "0" level of the switching selector-repeater in the branch offices to the toll board. The reason for this arrangement is that it places the C.L.R. holding, signaling and transmitting features in a relatively small number of trunk circuits, rather than incorporating these expensive features into the switching selector-repeater, which would be required if the branch office subscribers were to have access to their respective main office C.L.R. trunks. In most cases these trunks from the branch office to the toll board would be two-way trunks, and as such would also be used for inward toll calls to the branch office.

Third Digit Switching

Under certain operating conditions, particularly in smaller size switching selector-repeater offices,

considerable savings in equipment may be effected by using a switching selector-repeater which will switch on the first or third digit. Figure 5 shows a small network comprising one ten-thousand terminal main office and two branch offices of 500 terminals each. Five-digit subscriber's numbers are used throughout. The trunking between the main office and one of the branch offices is shown in more detail in Figure 6. The trunking between the main office and the other branch office is identical with the one shown in Figure 6, except that the subscribers' numbers in the latter branch office start with the digit "5".

For calls to the toll board the calling branch office subscriber will dial "0", and the switching selector-repeater will switch and rotate in on the "0" level and select a trunk to the toll board (switching on the first digit).

If a branch office subscriber wishes to call a local number, as for example 41564, the dialing of the first digit "4" will in the customary way operate both the switching selector-repeater and the incoming first selector in the main office to the fourth level. The switching selector-repeater will, by its circuit marking, recognize this as a local call, and will immediately cause the release of the incoming first selector in the main office, thereby freeing the main office trunk for another call. The switching selector-repeater, however, will not release at this time, but will remain operated with its wipers standing at the fourth level of the bank. The dialing of the next digit, "1", will rotate the wipers of the switching selector-repeater in on contact No. 1 of the fourth level. This causes the switching selector-repeater, actuated by the circuit marking, to release immediately and return to normal. The dialing of the third digit, "5", operates the switching selector-repeater to the fifth level, causing it to switch through and rotate its wipers in on the level, and select a trunk to an idle connector (switching on the third digit). The dialing of the last two digits operates the connector in the customary manner to the contacts of the wanted station.

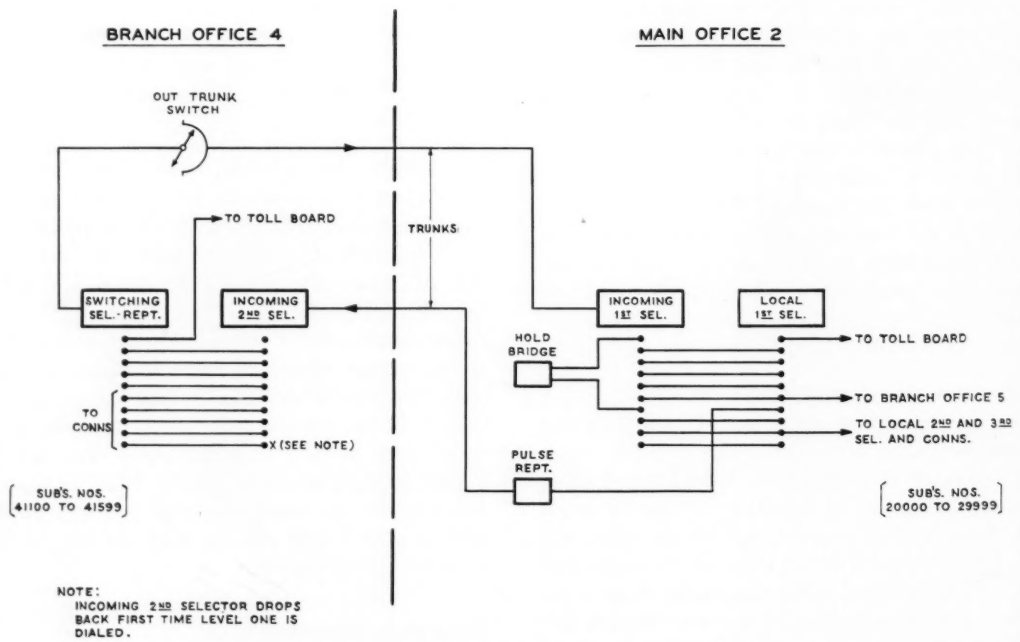

Figure 6. Trunking Detail Between Main and Branch Offices.

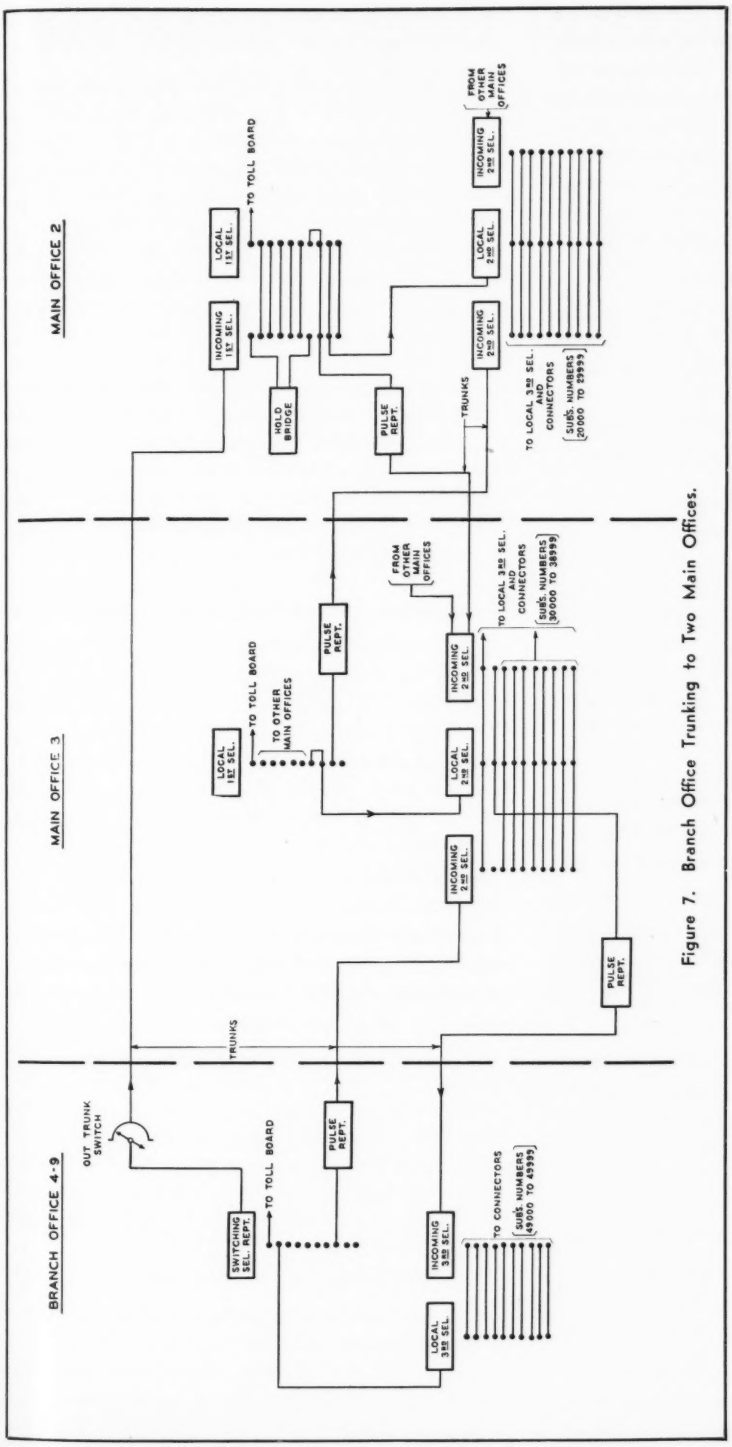

Figure 7. Branch Office Trunking to Two Main Offices.

Digit Absorbing Selectors

The incoming second selectors in the branch office are of the digit-absorbing type; that is, on incoming calls to branch office subscribers, the switch will immediately release and re-set after the digit "1" has been dialed the first time, thus absorbing the second digit ("1") of the called number. The second time the digit "1" is dialed, as for example on a call to a subscriber in the 41100 group, the selector will not release, but will switch through to an idle connector.

It will be observed from Figure 6 that holding bridges are connected to the fourth and "0" levels of the incoming first selectors in the main office. The function of these bridges is to hold the incoming selector operated during the brief period before the main office trunk is released on either toll or local branch office calls, thereby preventing the incoming selector from rotating to the eleventh horizontal step and returning a false busy to the calling subscriber.

From the foregoing it will be seen that the feature of switching on the third digit, and the digit absorbing arrangement of the incoming second selector, eliminate one rank of selectors.

Direct Trunking Application

Another interesting application of the switching selec-

tor-repeater is shown in Figure 7. The branch office is a branch of main office No. 3, inasmuch as it shares the ten-thousand terminals available to the No. 3 office. However, the first digit of the branch office numbers is different from the No. 3 office numbers. Main office No. 2 is the downtown office, and since the greater portion of the branch office originating traffic is for subscribers in the No. 2 office, the branch office is connected by direct trunks to the No. 2 office.

The switching selector-repeater in the branch office is of the type that switches on the first or second digit. Calls to main office No. 2 and to all other offices, except main office No. 3, tandem through No. 2 office. On such calls the switching selector-repeater merely functions as a repeater.

On calls to No. 3 office the switching selector-repeater will switch on the first digit ("3") and extend the call to an incoming second selector in No. 3 office. Simultaneously it will release the trunk to main office No. 2. The dialing of the remaining four digits of the wanted number will operate the incoming second selector, local third selector and connector in No. 3 office, in the customary manner.

On local branch office calls the switching selector-repeater will switch on the second digit of the dialed number ("9") and extend the call through a local third selector and connector to the called station.

It will be noted that the third and fourth levels of all main office local first selectors are multipled together. The reason for this is that all calls to branch office subscribers tandem through No. 3 main office.

As previously stated, the first digit of the branch office numbers ("4") is different from the first digit of the main office numbers ("3"). The use of a first selector level for trunking to a branch office permits the future conversion of the branch office to a main office to be made without the necessity of changing the branch office subscribers' directory numbers. This is a most desirable arrangement and should be made whenever first selector levels are available.

For the sake of simplicity, one-way trunks have been shown between main and branch offices. The switching selector-repeater, however, lends itself equally well to operation over two-way trunks, or combinations of one-way and two-way trunks, whenever economic advantages may be effected by such arrangements.

Advantages of Switching Selector-Repeater

From the foregoing briefly explained examples, it will be appreciated that in both large and small networks employing universal numbering the switching selector-repeater offers a practical and economical solution to the many problems involved in such areas. Its use may often eliminate a rank of selectors. It effects distinct savings in outside cable plant and provides a simple solution for obtaining universal directory numbers. In large metropolitan networks, employing Automatic Electric Company's Directors, it can successfully be used in such branch or sub-offices where the installation of Directors may not be warranted.

FORT WAYNE'S MOBILE TELEPHONE SYSTEM

By R. P. DIMMER

SYNOPSIS: ***Need in Fort Wayne for mobile telephones—history of mobile communication — Fort Wayne offers three types of service—FCC regulations governing mobile—physical description of Fort Wayne installation—technical description — operational procedures — performance observations—future of commercial mobile telephone.***

FORT WAYNE, the second largest city in Indiana, has seen a spectacular growth in the last quarter of a century. Its population has increased to the extent that it must now move beyond the city limits to obtain living facilities. To keep pace with this growth, continuous expansion has been shown by its industries and commerce. It is ideally located at the hub of four major transcontinental highways and many more minor but very heavily travelled state roads. Much of the traffic between Chicago and New York, Detroit and Indianapolis, and to other large cities in the south pass over these highways. With the completion of a super-highway providing a by-pass around the outskirts of Fort Wayne, a greater percentage of cross country traffic will be attracted to the use of this fast-moving highway network. The tremendous need for communication between land telephone network subscribers and trucks or automobiles which move along these thoroughfares in and around Fort Wayne has shown the necessity of furnishing a practical mobile radiotelephone service. To furnish such service the Home Telephone and Telegraph Company, Fort Wayne, has inaugurated a program of expansion incorporating a complete urban and highway mobile telephone system.

Mobile telephone, as discussed in this article, will be considered as a system for extending voice communication from Fort Wayne's present land telephone system to automobiles, trucks and other vehicles on a common carrier basis. Such service differs from the regular police, fire, or taxicab mobile systems in which a call from the central dispatcher is usually meant for more than one mobile unit. The service that we will describe is intended for general public use through the facilities of the local telephone company.

History of Mobile Telephone Communications

During the last quarter of a century, and particularly during World War II, the use of radio communication to the mobile unit has been increasingly evident. In view of the fact that it has raised the efficiency of movement of vehicles under military rule, it seems perfectly normal to assume that the businessman, doctor, or truck owner could be helped if he were to be provided with a similar means of communication whenever and wherever he is en route.

Telephone service between fixed and mobile units is far from new. Some of the earliest studies of radio telephony were concerned with ship-to-shore and ground-to-plane communications. The first commercial ship-to-shore system was inaugurated as early as 1929. Between 1929 and 1936 rapid advances were made. The individual signalling of ships was accomplished in 1936. This was probably the first development that appeared to have any application to a general mobile telephone system. Progress along these lines was slow in the early forties; however, directly after the end of World War II, several complete systems sprang into operation—a development which was accelerated particularly by the advent of frequency modulation. Both the highway and urban systems are now in operation in Fort Wayne and will be described hereunder.

Types of Service Offered

The Home Telephone and Telegraph Company is offering three types of service to meet the needs of various subscribers:

1. *General service,* which permits connections to be made from a mobile unit to any telephone in the public telephone system anywhere in the

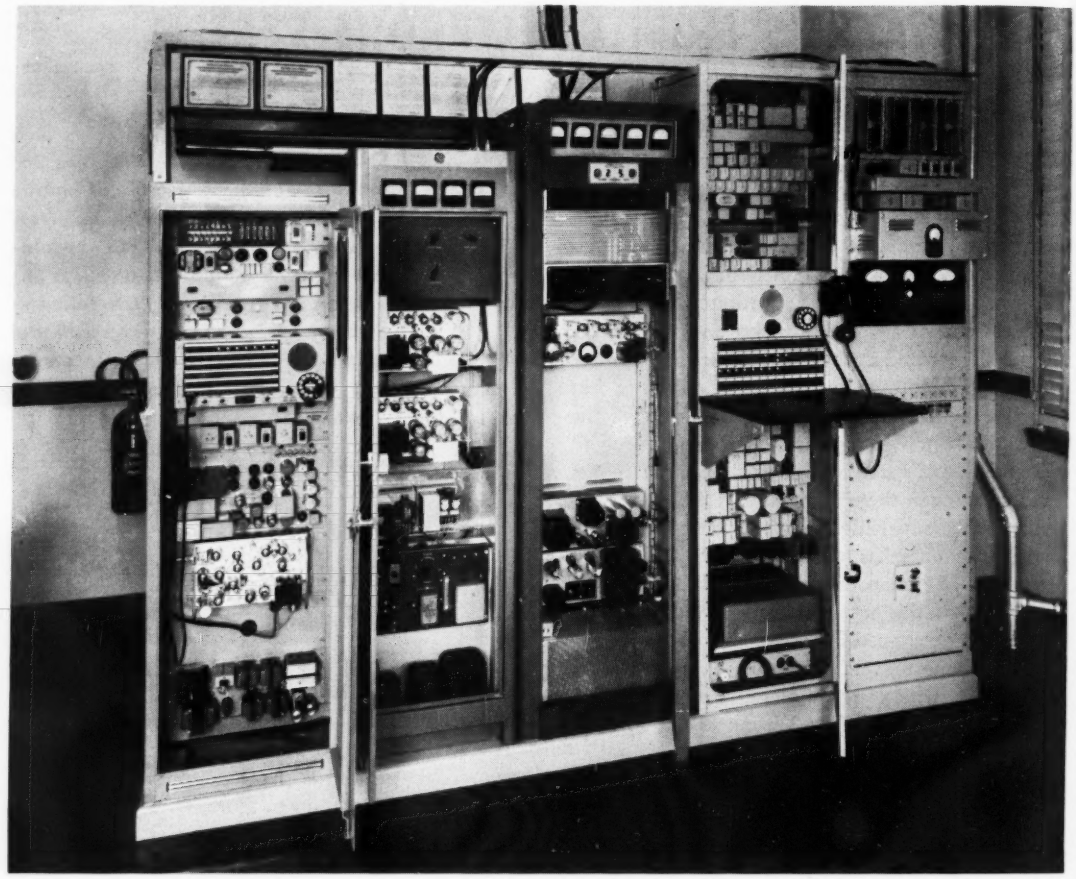

Fig. 1—Test room in the Fort Wayne telephone building, showing fixed transmitters and control equipment.

world. This also covers a call from one mobile unit to another. This service uses the three minute call as a basic unit of traffic.

2. *Dispatch service,* which provides for connections between a dispatch point and one or more vehicles. This service uses a one minute call as a basic traffic unit at a lower rate per call than for General Service.

3. *Signaling service,* which provides for signaling a specific unit to indicate that the operator of that unit is to take a prearranged action, such as calling his office from a nearby telephone. In this case the mobile unit is not equipped for transmitting.

Monthly service rates are actually based on "message units", the charge for each message unit being five cents. Each three-minute General Service call represents six message units and each additional minute or fraction, two message units. Each General Service subscriber is allowed a maximum of 120 message units. Each one minute call and each additional minute or fraction is counted as three message units in Dispatching Service. Each call on Signaling Service is counted as two message units. (These rates are for calls within zone 1 of what is normally termed the "local mobile service area".)

Systems and Wavelengths Permitted by the FCC

Two types of general mobile telephone systems have been provided for in the Federal Communi-

cations Commission allocation plan: Limited Area (Urban System) which operates in the 152-162 megacycle range and is generally intended for local traffic over a small area—usually a city and its surrounding suburbs; and the Extended Area (Highway System) which operates in the 34-44 megacycle range and is intended to provide continuous service to vehicles moving along highways or vessels along waterways between cities. These allocations are correct to October, 1948; however, at the present time, the FCC is considering changes in classes of services and frequencies allocated to the common carriers:

To conform with plans along these lines, certain letters and numbers have been assigned to vehicles in accordance with their ranges of travel as follows:

Urban System:

WJ2—Full roaming anywhere in U.S.A.

WJ5—Extended roaming 250 miles maximum

WJ6—Local Urban

WJ7—Limited roaming—100 miles maximum

WJ9—Signal Service—One way only

Highway System:

ZA—Any vehicle using the highway system whose registration point is Fort Wayne and surrounding area. This area includes Illinois, Indiana, Wisconsin, Michigan, Ohio, Kentucky, and Tennessee.

ZB, ZC, ZD, etc.—These prefixes are assigned to vehicles registered in other sections of the country.

The subscriber to mobile telephone service has agreed to abide by the provisions of the Federal Communications Act, the rules and regulations of the Federal Communications Commission, the terms of the station license, and the tariff of the Home Telephone and Telegraph Company. These rules and regulations cover the use and identification of the mobile radio station, and forbid the use of profane or indecent language, the transmission of false or fraudulent signals of distress, or the willful interference with any other radio communication.

Location of Radio Equipment

In the Fort Wayne mobile system all radio equipment for the urban and highway systems, with the exception of the receivers, is installed in the test room of the Anthony telephone exchange building (Figure 1). Since this room is attended 24 hours a day, any operational difficulty can be quickly detected. Alarms are also extended to the switchroom, one floor below. The location of the radio equipment is convenient to the source of required power, both 48 volts d-c (exchange battery) and 115 volts a-c (commercial power). The transmitting antennae for both the urban and highway systems are located on the roof of the telephone building directly over this test room. These antennae are separated from each other by approximately 30 feet and have an average height above ground of 65 feet. Both are mounted on three-inch pipes, swiveled at the base to permit ease of lowering for repair and painting. The antennae for the test transmitters in both systems are located in the attic of the main building.

The local receivers for both systems are remotely located in the room directly off the observatory level on the top of the Lincoln Tower Building

Fig. 2—Lincoln Tower, Fort Wayne (location of local fixed receivers).

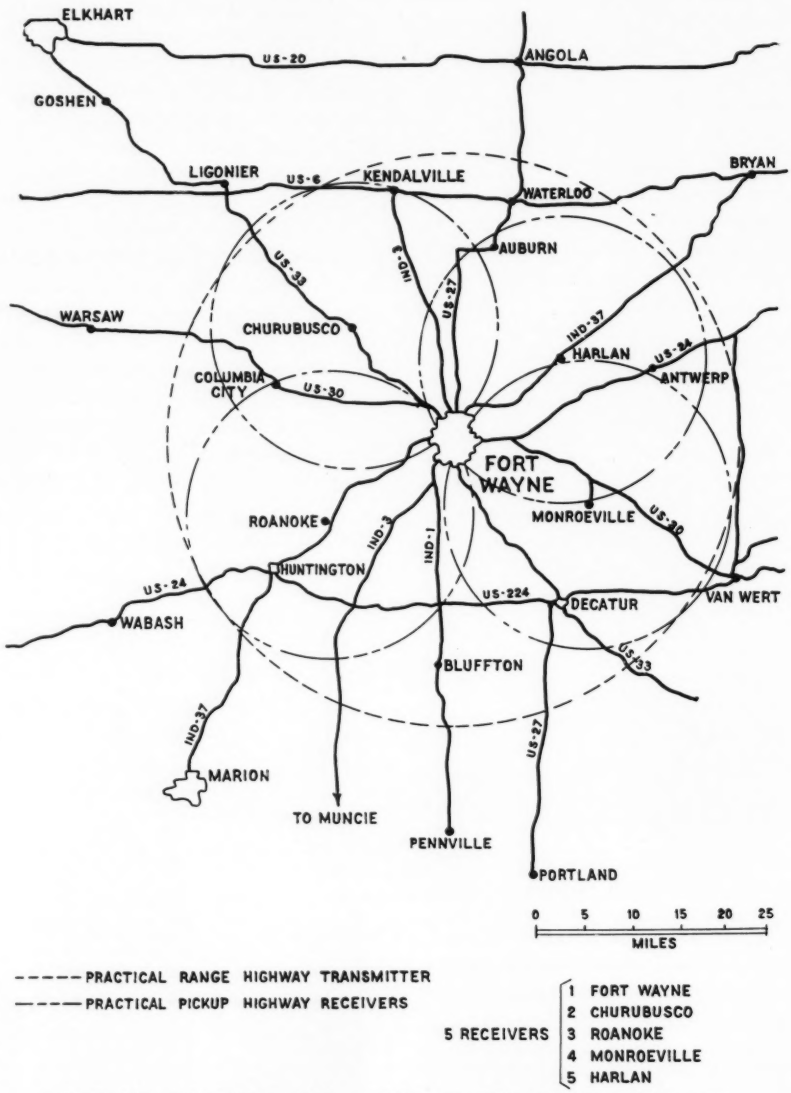

Fig. 3—Map of Fort Wayne and surrounding area, with probable receiving range (Highway System).

in Fort Wayne (Figure 2). This building is located in the heart of the downtown section approximately two blocks from the main telephone office. It has a height of approximately 300 feet. Due to its position and type of antennae used, the measured horizontal plane directivity pattern is almost completely non-directional. Both receiving antennae are clamped to the vertical columns supporting the upper dome structure.

At present the receivers located on the Lincoln Tower are the only ones in operation on each system. To cover a greater area with the highway

system, however, it is planned to add four more receivers throughout the surrounding countryside. Three of these proposed units will be mounted directly on standard telephone poles. These will be located in the outlying towns of Roanoke, Monroeville, and Harlan. The fourth receiver will be located in the local telephone office building at Churubusco with the antenna mast directly adjacent. Figure 3 shows the area around Fort Wayne and the proposed locations of these receivers, together with their theoretical relative reception characteristics. Each of the three pole receivers will be mounted in a weatherproof housing at the base of a 70-foot cedar pole which will also serve as its antenna mast. Topography maps of this area are unavailable at this time, and as a result these sites had to be selected on the basis of apparent elevation and a low noise level. A preliminary survey was made with a temporary installation at each of these points before the site was selected as final. All sites are convenient to power and local office cable.

Fig. 4—Radio equipment and selector in vehicle.

Technical Description of Equipment

The land radio transmitter for the urban system is a Link frequency-modulated unit rated at 250 watts output on a frequency of 152.63 mc or a wavelength of about 1¾ meters (Figure 1). This unit is crystal controlled with a crystal frequency of 1/96th of the operating frequency. Frequency multiplication is afforded by the use of 3 doubles, 1 quadrupler, and 1 tripler stage. The carrier is phase-modulated with approximately 600 watts input to the final tubes at rated power. These tubes are forced-air-cooled, and reach a cherry red color after a few minutes of operation. A parallel line is used as the output resonant circuit.

The urban transmitter feeds a solid dielectric type transmission line. This line is a recent development now finding very widespread use. Its solid dielectric material is polyethylene. It in turn feeds a 51-ohm half-wave colinear coaxial antenna so designed that an overall gain of 3 to 4 in power is obtained over the conventional half-wave type. The outer skirt of the antenna is grounded through the transmission line shield for lightning protection. To isolate this system from the telephone equipment, a separate "earth" ground is provided.

Coupled to the transmitter by a small pick up loop is the urban frequency monitor, shown mounted on the rack to the extreme right of Figure 1. This monitor provides an alarm which notifies the technical operator on duty if the land transmitter varies in frequency by 0.004% or more. The use of a similar automatic device has been deemed satisfactory by the FCC for radio stations of this type that are unattended. A third class operator is in the vicinity at all times to turn off the equipment in the event of alarm, and a second class operator is available on call to make any necessary readjustments.

Adjacent to the transmitter is the urban control terminal which serves as the interconnecting link between the toll switchboard and the radio equipment. In it are contained all test, monitoring, and terminating circuits, the selective signalling oscillators to furnish tone for signalling, various channel amplifiers, and a voice operated constant level amplifier.

A test transmitter and monitor receiver are main-

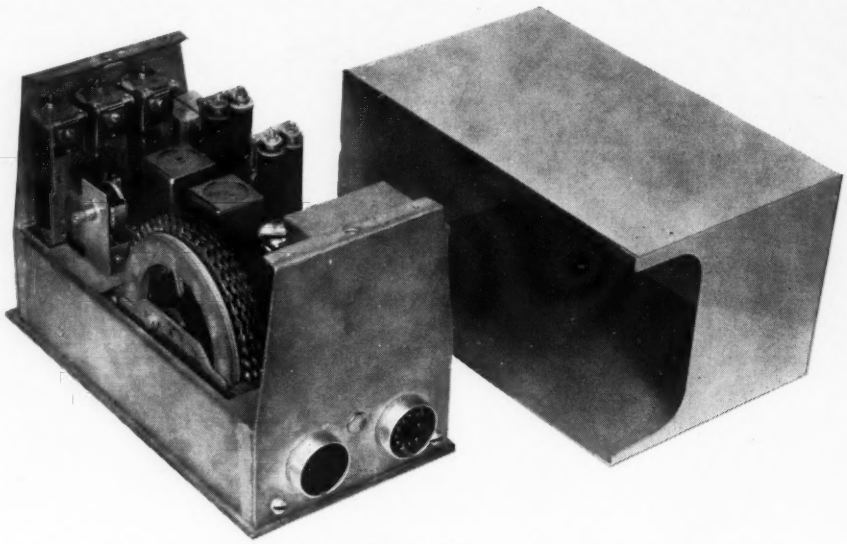

Fig. 5—Mobile selector with cover removed.

tained at the terminal to check both receiving and transmitting characteristics of the land station equipment. The test receiver is operated 24 hours a day to provide continuous monitoring of the outgoing transmission, whereas the test transmitter is operated only during test periods. Both units are kept in the bottom shelf of the urban control terminal cabinet.

The land radio transmitter for the highway system is a General Electric frequency modulated unit conservatively rated at 250 watts output on a frequency of 35.42 mc (Figure 1). It is also crystal controlled with a crystal frequency of 1/32 of the operating frequency, and phase modulated with a deviation of ± 15 kilocycles at a 100% modulation swing. As a result of the greater efficiency possible at these frequencies no forced cooling is required.

Directly to the left of the highway transmitter is its control terminal. This unit was designed in the Automatic Electric Laboratories to provide a foolproof unattended control terminal for mobile telephone systems. The following sub-units comprise this control terminal:

(A) Amplifier Unit—On this base are contained both the amplifier to raise the signal level from the remote receivers as well as the amplifier to give the speaker volume from the local monitor receiver.

(B) Dial Tone Unit—This panel contains all control circuits and 600-1500 cycle oscillator circuits for signalling tone to the radio transmitter.

(C) Terminal Control Unit—This unit contains all control (switchboard to radio), terminating, test, and monitoring circuits. Also contained in this unit are a jack and lamp sub-panel for testing in and out or bridging any point in the circuit, and a test dial and monitor speaker.

(D) Constant Level Amplifier Unit—This unit is a voice operated, constant level amplifier which keeps the voice level to the radio transmitter at a constant value even under conditions where the incoming speech levels vary by as much as ± 20 db from a mean value. During periods of no speech the gain adjustment automatically decreases to a very low value.

(E) Incoming Receiver Control Unit—Contains terminating and incoming signalling circuits.

(F) Power and Fuse Units.

The transmission line and antenna for the highway transmitter are identical to that used on the

Fig. 6—Dash unit mounted in vehicle.

urban system with the exception of the difference in length of radiator element. An automatic frequency monitor is also in operation to warn if the transmitter should deviate from its assigned frequency.

Both transmitters are equipped with overload or excitation failure controls. If the final tubes in either unit should draw excessive plate current for any reason, the power will automatically be disconnected and a warning signal will be sent to the technical operator.

The receivers for both systems are of the double conversion type, capable of receiving frequency modulated signals with a deviation of ± 15 kilocycles. For stability these units are crystal controlled with an incoming signal frequency of 157.89 mc for the urban and 43.42 mc for the highway. All receivers are connected to their antennae by standard 50-ohm solid coaxial transmission line. The antennae used for the local fixed receivers on Lincoln Tower are of the half-wave coaxial type, whereas use of the Unipole type of antenna has been proposed for the remote units. Both types of antennae have given about equally good results. Vertical polarization of the radiated signal is used on both systems. The audio signal from each receiver is fed over a physical pair from each remote installation to the central office main frame, where it is distributed to the terminal on either system. When multiple receivers are used, a receiver with the greatest signal-to-noise ratio is selected. This also prevents phase distortion which would otherwise occur if the signals from more than one receiver were fed into a single circuit. If the mobile unit travels from one receiver region to another, this unit will be switched to the receiver with the greatest signal level.

Mobile Station

The mobile station (Figure 5) contains essentially the same type of transmitter and receiver as the land station with the exceptions that the power for the mobile unit is obtained from the vehicle battery rather than a commercial source, and the output rating of the mobile transmitter is between 15 to 30 watts. Special consideration is given the design of the mobile units in view of the fact that they must perform satisfactorily over very rough terrain, and under temperature changes from -30°F to over 120°F.

In the mobile unit a single antenna is used for both transmitting and receiving. Pressing the talk-listen button on the handset automatically transfers this antenna from the receiver to the transmitter. On the urban system the antenna used is a single piece of steel rod 18 inches in length, mounted directly in the center of the roof of the car (Figure 7). If the vehicle has a fabric top it is usually necessary to lay a strip of wire screening on the surface of the roof to similate a ground plane in order to get the greatest efficiency from an antenna of this type. For the highway system a six-foot whip type antenna is used, normally mounted on the side of either rear fender (Figure 8). This type of antenna is coupled through a capacitor to the transmitter to give high voltage protection in case of contact with low hanging trolley wires.

The heart of the mobile telephone system is

the selector (Figure 5), designed by the Automatic Electric Laboratories. This unit receives the dialing pulses from the land station, and operates a call buzzer and lamp in the particular unit which is wired to the terminals represented by the code which is dialed. The selectors on all other vehicles on the same channel fail to complete the cycle of operation and cause these receivers to be "locked out".

The control or dash unit, Figure 6, containing the handset, indicating lights, and power switch, is usually mounted under the dash panel of the car to the right of the driver. This unit was designed by the Automatic Electric Laboratories and can be conveniently mounted in practically any make of car or truck. On the front panel is a green "power" lamp, a red "busy" lamp, and a white "call" lamp; inside is the buzzer. From this unit the subscriber knows if the power to the radio equipment is on, whether the radio channel is busy, and if he is being signalled, either audibly or visually. If the subscriber is not in the vehicle at the time the call is received, the call lamp will remain operated until he returns to the vehicle and calls the operator.

The current consumption of the mobile units varies somewhat, but the average model draws approximately 7 to 9 amperes continuously for the receiver and selector, and 2 to 3 amperes for the transmitter. This is only a little greater than the consumption of an ordinary automobile radio receiver. When the mobile transmitter is on the air, approximately 35 to 45 amperes are drawn. This may seem extremely high; however, it should be remembered that the average transmitter is only on the air when the mobile subscriber talks. The complete mobile telephone call usually average 1½ minutes, and of this about ½ represents talking. The actual power consumed by the transmitter over a period of time, therefore, is not excessive.

Operation of Equipment

A connection from a land subscriber to a vehicle is made as follows: The subscriber obtains the mobile service operator over the wire line network in the usual way, and gives her the telephone number of the vehicle desired. This service is usually handled by a regular operator on the toll switchboard unless the traffic is large enough to warrant a separate mobile service position. This number consists of two letters and five digits, such as WJ6-3923. The operator plugs into the jack associated with the mobile system, and after waiting for the "start dialing" lamp, dials the number requested. This causes alternate pulses of 600- and 1500-cycle tone to be radiated by the land station to operate the selectors of all vehicles on that channel within range of the transmitter.

Fig. 7—Mobile unit with urban antenna.

The selectors in all the mobile units on that channel will step in accordance with the code dialed. As soon as one of the digits dialed is not similar to the one assigned the called vehicle, that unit will be locked out and the operation of the selector stopped. This lock-out prevents the units not being called from either interfering with or listening to the established call. The switch of only one unit in the channel will travel the full distance of 23 steps (the sum of all the digits in each number in the present two-way mobile system equals 23). At this point a buzzer in the mobile unit called will operate. At the end of four seconds a 24th pulse is sent out automatically from the central office. This disconnects the buzzer and operates a call lamp which will remain operated until the mobile subscriber calls the operator. This not only provides an automatic 4-second calling period, but it also provides a means whereby a subscriber can be signalled even though he is not in the vicinity of the vehicle at the time. On the units which are locked out, a red busy lamp will remain operated until the channel is again free.

In completing a call from a mobile to a land subscriber, the mobile subscriber has only to remove the handset and press his talk-listen button for a moment. If the mobile unit is within range of any receiver, the reception of this mobile radio carrier will operate a call lamp at the switchboard. The mobile service operator will then dial into the land line network the number of the subscriber requested. Conversation between the mobile unit and a land subscriber is carried on exactly as if it were a regular wire connection with the exception that the mobile subscriber must operate his "press-to-talk" button to talk, and release it to listen.

If a mobile subscriber wishes to contact another mobile unit on the same system, he has only to give the mobile service operator the telephone number of the unit desired, and wait a few moments. The operator will remove the plug from the jack associated with the same mobile channel for a second. When she replaces the plug into the jack the radio transmitter returns to the air, this time with dial tone. The operator will then dial the called party. During this period the calling party is standing by, awaiting instructions from the operator. When the called party answers the operator will give the go ahead signal and two way conversation can then be carried on in the usual way. For supervision the operator will monitor the call at 15 second intervals.

Interchannel calls between an urban mobile unit in one city and a highway mobile unit in another can be made and carried on just as easily. The mobile unit in one city will be connected by radio with the local telephone company, thence by the long-distance wire-line network to the other city in the immediate vicinity of the second mobile unit, and finally by radio to this second unit. In setting up a call between two mobile units in communities separated by large bodies of water, there will be brought into the network still a third radio system spanning the body of water.

Performance

During the initial tests of the urban system, excessive pickup by the receiver of the signal from the fixed transmitter was the greatest difficulty. Without a very highly selective receiver to reduce this feedback from the transmitter, it was necessary to separate the fixed transmitting and receiving antennae by a greater distance. It was found necessary at first to separate them by at least 1½ miles. Feedback under these conditions in itself was not objectionable; however, when it occurred, the local taxicab station would ride in on the signals, and in some cases would take over complete control of the channel. Another serious interference, although not as frequent, is apparently caused by diathermy or radio frequency heating equipment in the immediate neighborhood. This type of interference is also causing the police department's radio units similar headaches. Because of its intermittent nature the source of this disturbance has not been found.

Fig. 8—Mobile unit with highway antenna.

The Lincoln Tower building (Figure 2) was finally selected as the best location for the local fixed receivers. With this tower as receiver site, communication between the mobile unit and the wire line subscriber on the urban system can be carried on for a distance of 10-12 miles from town. This covers the greater part of Allen County. Due to the peculiar saucer-like topography around Fort Wayne, it does not seem possible to better this distance unless the height of the transmitting antenna is raised considerably. At the present time transmissions are going beyond the line of sight which is the practical limit for good commercial operation.

Some interference was encountered from the motor generators in the mobile units. This has been remedied by replacement. Very little ignition and

motor noise has been observed on the urban frequency. To be on the safe side, a generator condenser and distributor suppressor were used, where possible, to remove the noise that might later develop after the brushes wear. In older vehicles it is sometimes necessary to raise the generating rate to compensate for the higher drain on the vehicle's battery; newer vehicles generally handle this automatically.

On the highway system it was possible to cruise 30 to 35 miles in most directions and still pick up the land carrier station. Our talk back from the mobile unit was still about the same as with the urban 10 to 12 miles. To furnish the service required on these frequencies the installation of four remote receivers has been proposed to bridge the gap to the outer fringe of the land transmitter range.

Very little interference was encountered on the highway fixed station. It was sometimes possible to receive the fixed stations from other systems in the surrounding larger cities on our monitor receiver but such interference was intermittent. Ignition interference on the mobile units was more pronounced on these frequencies, and more elaborate precautions had to be exercised to eliminate it. The highway system's radiation pattern seemed to change with time of day, whereas no such effect was noted on the urban system.

Outlook for the Future

Under the present setup, it appears that 75 to 100 is the maximum number of mobile units that can be placed on one channel. If a city has a demand for 10,000 units it would be necessary to have at least 150 channels. At the present time the F.C.C. has allotted only two complete two-way channels for this service; the third having been taken away only recently. It appears that before mobile telephone service can become nationwide on a large scale, it will be necessary to provide a more liberal frequency allocation.

In order to make use of every channel, receivers will have to be designed with better adjacent channel rejection. Operation of all channel carriers to prevent interference is not a satisfactory solution as it prevents a "private line" selector from being used.

In addition to service to vehicles, there has been a considerable demand for general telephone service in private yachts, barges, ore boats, lake freighters, airplanes, and railroads. Experimental installations along these lines are already in operation in several places.

INTERCEPTING SERVICE FOR STROWGER AUTOMATIC TELEPHONE SYSTEMS

By H. A. DIEZEL

SYNOPSIS: ***Uses of intercepting service — connecting in terminal per station and terminal per line offices, and combinations — methods of identifying stations on party lines—harmonic ringing, code ringing, and matching pulses — unattended "wrong number tone"—reaching the operator—intercepting toll calls.***

TO telephone operating companies, intercepting service means the provision of a spoken or tone announcement to a subscriber that he has dialed a number requiring correction. This service assists the calling person, because he receives an immediate explanation when he first attempts to call a line "on intercept", and it assists the called person, because those trying to reach him are at once advised that his number has been changed or that his line is "on intercept" for some other reason. At the same time the service benefits the telephone company, since it forestalls the tying up of equipment during successive attempts to call a non-existent or changed number, eliminates excessive non-revenue holding time of toll circuits on calls to incorrect numbers, and speeds up inter-toll dialing traffic.

In the typical Strowger Automatic exchange, intercepting service may be applied in any or all of the following cases:

(1) Changed numbers (an individual-line subscriber moves out of the office area, or a party-line subscriber in a terminal per line group moves out of the line range or office area).

(2) Directory errors.

(3) Take-outs (probably at an all-time low, due to present conditions).

(4) Unassigned terminals (in both terminal per station and terminal per line offices).

(5) Unassigned stations on party lines (can be intercepted up to 10 stations per line, on either code or harmonic ringing lines).

(6) Plugged-up lines (for temporary disconnect or secretarial service, while still permitting outgoing service from the lines).

(7) Vacant selector levels (on either local or toll selectors).

In offices where an operator answers intercepted calls all of the above classifications are routed to her, by means of various types of equipment explained below. In small offices, where the cost of equipment for routing such calls to an operator is not warranted, an inexpensive type of intercept service is available in the form of a tone, usually called "wrong number tone".

Terminal Per Station vs. Terminal Per Line

In a terminal per station office, where the connector terminal can readily be disconnected from the line relay, intercepting is relatively simple, since many connector terminals can be bunched and terminated on an intercept trunk or line equipment. At the line intermediate distributing frame, where the connector terminals are connected to three-pin blocks, the three-wire jumper to the line equipment is replaced with one running to the intercept terminal block.

In recently installed offices connector terminals are connected to six-pin blocks with each of the +, — and *C* rows of terminals having an adjacent common strapped row of terminals which constitute the +, — and *C* of the intercept circuit. With this type of pin block arrangement the usual long jumper to the intercept circuit terminal block is not required. After removing the jumper to the line equipment, all that is needed is to strap the +, — and *C* of the connector terminal intended for intercept to the adjacent strapped rows of terminals with short bare wires.

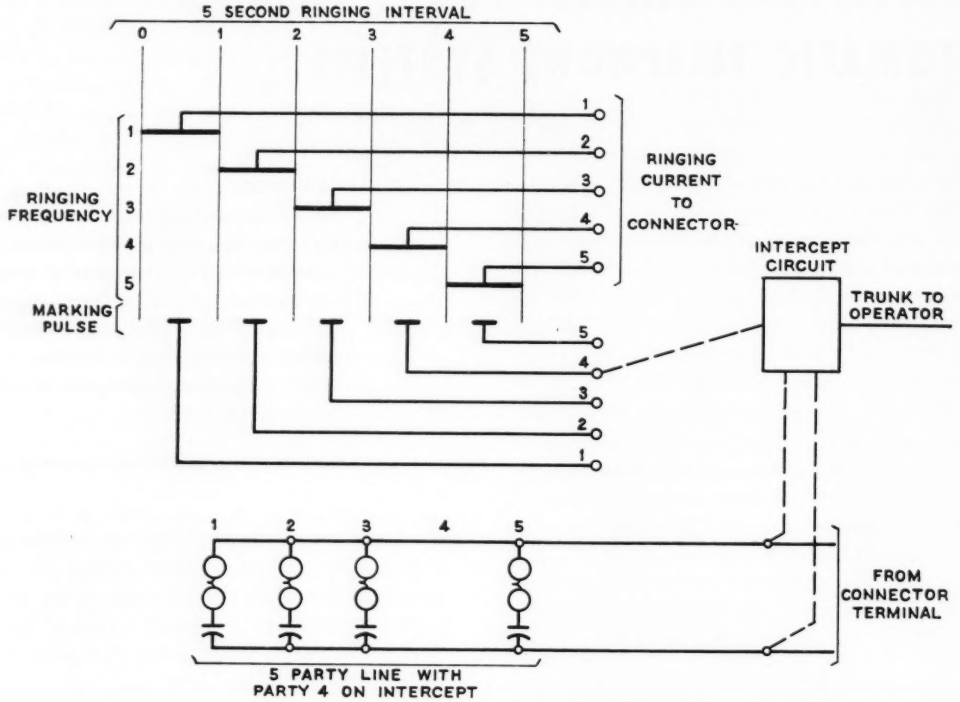

Figure 1. Intercepting a Frequency Ringing Line.

There are two distinct types of terminal per line offices. One has the connector terminal and line relay permanently connected. Since separating them is difficult, bunching of terminals is not possible and each terminal on intercept requires a separate intercept line equipment. The other type uses a line intermediate distributing frame primarily for distribution of traffic but also permitting individual line connector terminals and unassigned connector terminals to be bunched and carried to the intercept operator as required.

From an equipment standpoint, party lines on a terminal per line basis present the only real problem when it is necessary to intercept one or more stations on a line. An intercepting arrangement is therefore necessary which will discriminate between the party or parties "on intercept" and those still working. Identification of the station "on intercept" can be accomplished in several ways:

(1) For two-party lines with divided ringing to ground, the intercept circuit can be connected to the + or — side of the line to correspond to the party disconnected.

(2) Harmonic-ringing party line stations "on intercept" can be identified with tuned a-c relays connected to the + or — side of the line to correspond to the party disconnected. This method is applicable to five-frequency harmonic ringing, bridged or divided.

(3) Code-ringing party line stations as well as harmonic-ringing party line stations "on intercept" can be identified by the ringing period and an associated matched intercept pulse arrangement.

(4) Stations on 20-party code ringing lines can be identified by an actual check on the code ring, although this method is generally too costly except for very special applications.

Use of the Matched Intercept Pulse

The third method above requires a detailed explanation. The scheme is applicable to many classes of service, including individual lines, two-party lines with bridged harmonic ringing, two-party lines with divided ringing to ground, four-party lines with semi-selective divided ringing to ground, five-party lines with bridged harmonic ringing or bridged code ringing, and 10-party lines with bridged one- and two-ring harmonic ringing or with divided code ringing.

The scheme requires that the ringing interrupter be equipped to produce a separate matching pulse for each frequency or code at a time when only that frequency or code is transmitted over the line. The intercepting circuit is designed to function only when it receives ringing current representing the intercepted station's ringing period, and the associated matching pulse through the customary cross-connection. During the ringing period of working stations on the same line, the intercept circuit does not function, since the matching pulses for these stations are not cross-connected to it. If two or more stations on the same line are placed on intercept, their marking pulse is also cross-connected to cause the same intercept circuit to function.

Figure 1 is a diagram of this cross-connection, as applied to a harmonic-ringing line. It will be seen that all frequencies are not applied simultaneously to a connector group and that, in order to equalize the load carried by the harmonic converter, each frequency is divided into five periods. Accordingly, an exchange having 500 lines or five connector groups would have the load of the first frequency spread evenly over the five-second ringing period, with one second per connector group.

Because the five frequencies are applied at different one-second intervals it is simple to produce a separate pulse to match the period of each frequency. The frequency and matched pulse are always associated regardless of the one-second period in which they are applied.

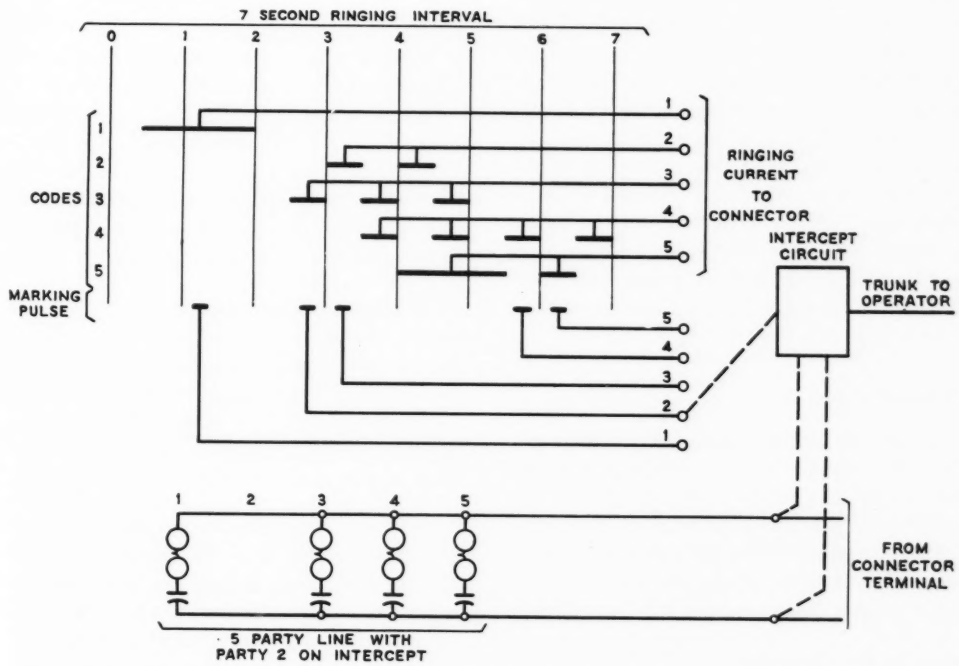

Figure 2. Intercepting a Code Ringing Line.

Figure 2 is a diagram of the cross-connection as applied to a code-ringing line. In contrast to harmonic ringing, code ringing has only one converter to produce ringing current for all codes. In this case, the length of time required to produce all codes in the ringing interval and still equalize the simultaneous load is seven seconds. All connector groups receive the coded ringing simultaneously. The matched pulse associated with each code is again produced only at the time when that code alone is being transmitted over the line.

The intercepting line relay connected to a line on this service operates partially each time ringing current is applied to the line. However, it does not complete its function until the matched pulse is applied. It therefore requires a combination of both the ringing current and the matched pulse, properly cross-connected to the intercepting equipment, to identify the station.

Mention was made previously of the different means of providing intercepting service in a terminal per station office and a terminal per line office. There are, in addition, some terminal per station offices which handle rural stations on one or more groups of terminal per line, party-selecting connectors. These rural stations, moreover, may be reached through code ringing, whereas the terminal per station groups use harmonic ringing. Intercepting in such offices merely uses both types of equipment: terminal per station connector terminals are connected directly to intercepting trunk or relay equipment, while a small amount of ringing period matched pulse intercepting equipment is provided for identifying stations on the rural lines. The trunks to the intercepting operator are able to handle both types of intercept calls.

Vacant Selector Levels

Intercepting on vacant selector levels poses no problem. The vacant levels, for both local and toll selectors, can be bunched and extended to the opertor over trunks separate from those used for regular line intercepting. When the operator answers a call over one of these trunks, she knows in advance that a non-existent number has been dialed.

Extension to the Operator

The method used for extending intercepted calls to the operator varies with the type of office — whether small or large, attended or unattended — and the facilities available between offices if the calls are extended over trunks. In small unattended offices, for example, calls can be extended over one of the trunk circuits to the master office. The trunk usually used is the one which is last choice for regular toll calls. If this trunk is occupied with a toll call, the person calling the intercepted terminal receives the usual busy tone. If the trunk is occupied by another intercept call, the subscriber hears ringback tone until the first intercepted call is completed. The waiting call is then extended to the operator. As an alternative, a trunk finder, usually a rotary switch, can be provided to seize any idle trunk to the operator for extending the intercepted call.

When unattended sub-offices are arranged with separate groups of toll and free-service trunks, the free-service trunks usually terminate on incoming selectors in the main office. The intercept operator is then distinct from the toll operator. In such cases a digit sender is associated with the intercept circuit to step the main office incoming selector and special service selectors to reach the intercept operator.

In large offices, concentration units are used to channel the intercept traffic to one or more trunks. These units are of the linefinder type, available in sizes of 25, 50, 100 and 200 intercept line equipments and from 1 to 10 trunks to the operator which terminate on answer jacks. Such concentration units can be used whether the operator is in the same office or in a distant office.

In a terminal per station office, each 100 connector terminals or more are usually allocated to one intercept line equipment at the line intermediate distributing frame. Stations placed "on intercept" are strapped or jumpered to a line equipment which is seized by the linefinder; each call is then automatically routed to the intercept operator.

If a small PBX group is placed on intercept, only the pilot number need be connected. However, if the group is large, then it would be preferable to reduce the total number of trunks in the group and connect both the pilot number and the remaining trunks to separate intercept line equipments. This method allows intercept operators to answer simultaneous calls to a busy PBX group.

In the terminal per line office, where it is not possible to disconnect the connector terminal from the regular line equipment, a correspondingly larger number of intercept line equipments is required. This is necessary since every line on intercept would require an intercept line equipment.

The intercepting operator has complete records of changed numbers, take-outs and errors, so she can give the calling subscriber or toll operator the necessary instructions rapidly.

In small offices which use a "wrong number" tone to advise subscribers that they have dialed a changed or discontinued number, it is necessary to provide directory instructions that the subscriber should hang up and then call the regular toll operator for advice.

Telephone companies having offices, either small or large, which participate in inter-toll dialing should provide operator intercept service. A distant toll operator calling a number "on intercept" would be routed to the intercept operator, and the latter on answering would receive a distinctive tone identifying the call as a toll call. Special handling is necessary since the distant toll operator would receive answer supervision when the intercept operator plugs in, and would normally start timing the call. To avoid this the intercept operator moves her ringing key to flash the distant operator and give her the necessary instructions, instead of talking to the calling subscriber.

Cost of the equipment and cost of the operator's time are the two factors governing the application of intercepting service. These factors will, of course, vary with the type and size of office. This article has shown that equipment is available for many different types of offices contemplating an expansion of intercepting service. A study of all the requirements and facilities would determine the most economical and practical solution to present and possible future needs of the community.